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ABSTRACT

This study used cued dichotic listening to investigate differences in language lateralization among right-handed (control), left handed, bilingual, and learning disabled children. Subjects (N=60) ranging in age from 7-13 years were administered a consonant-vowel-consonant dichotic paradigm with three experimental conditions (free recall, directed left, directed right). A three-factor analysis of variance design revealed that control, bilingual, and learning disabled children produced the expected right-ear advantage (REA) suggestive of left hemisphere dominance for language processing whereas left-handed children produced a left ear advantage suggestive of right hemisphere superiority for language processing. The cued attention data derived from groups as well as from individual subjects suggested that in comparison to control children, left-handed children were greatly susceptible to attentional shifting similar to learning-disabled children but in the opposite hemisphere. Bilingual children were found not to be as strongly lateralized as controls but possibly less susceptible to attentional manipulation. Further lambda analyses conducted on individual subjects indicated that the magnitude and degree of perceptual asymmetry varied widely among some individuals of various anomaly groups. These findings lend support to the hypothesis that attentional factors have a greater influence on asymmetrical functioning for some anomalous groups of children (i.e., left-handers and learning-disabled) while not affecting others (i.e., controls and bilinguals). (Author)

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Cued Dichotic Listening With Right-Handed, Left-Handed, Bilingual and Learning-Disabled Children

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Abstract

This study used cued dichotic listening to investigate differences in language lateralization among right-handed (control), left-handed, bilingual, and learning-disabled children. A sample of 60 subjects ranging in age from 7-13 years were administered a CVC dichotic paradigm with three experimental conditions (free recall, directed left, directed right). A three-factor ANOVA design conducted on the data revealed that control, bilingual, and learning-disabled children produced the expected REA suggestive of left hemisphere dominance for language processing whereas left-handed children produced a LEA suggestive of right hemisphere superiority for language processing. The cued attention data derived from groups as well as from individual subjects suggested that in comparison to control children, left-handed children were greatly susceptible to attentional shifting similar to learning-disabled children only in the opposite hemisphere. Bilingual children were found not to be as strongly lateralized as controls but may be less susceptible to attentional manipulation. Further, lambda analyses conducted on individual subjects indicated that the magnitude and degree of perceptual asymmetry varied widely among some individuals of various anomaly groups. These findings lend support to the hypothesis that attentional factors have a greater influence on asymmetrical functioning for some anomalous groups of children (i.e. left-handers and learning-disabled) while not affecting others (i.e. controls and bilinguals).

Introduction

Results from normal (control) children using the dichotic paradigm have shown that most right-handed children produce a right-ear advantage (REA), suggestive of left-hemisphere language lateralization, but evidence is either mixed or lacking among more anomalous groups of children such as the learning-disabled, bilingual, or the left-handed child. In fact, mixed results for clinical groups of learning-disabled children have prompted researchers to question the REA in these special populations, and has resulted in the refinement of the dichotic listening task. Through work with carefully selected learning-disabled children it has become evident that a conceptualization of the REA based solely on structural considerations does not satisfactorily account for all the data. The studies conducted by Obrzut and his colleagues have basically shown that learning-disabled children produce an REA but to a lesser extent than that reported for control children, and that the results can be interpreted from various attentional and cognitive strategy hypotheses as suggested earlier by Bryden. To the extent that these strategies or task parameters influence performance, they may dictate the magnitude and even the direction of the observed laterality effect. Thus, investigation of differences in speech and language lateralization among children with presumably anomalous cognitive processing abilities may help clarify whether the observed laterality effects are primarily due to attentional bias

or to an asymmetry of perceptual discrimination.

Research into the cerebral lateralization of bilinguals has resulted in conflicting findings, including the LEA for language processing in some brain-damaged bilinguals. However, many of these studies have serious methodological flaws which may account for the contradictory results. Converging evidence appears to be accumulating in dichotic listening studies with adult subjects for equal levels of left hemispheric dominance for language in monolinguals and bilinguals. However, little research has been done with bilingual children.

To date, in the majority of dichotic listening studies using children as subjects, left-handed children have been intentionally eliminated due to their presumed confounding effect. While hemispheric specialization in the normal brain of right-handed subjects has been well documented, left-handers appear to be more heterogeneous with respect to the direction and degree of cerebral specialization. Some left-handers show an REA on dichotic tasks, whereas others show either an LEA or are more bilateral in organization. It is not clear from the research which factors distinguish between left-handers with these different patterns of cerebral specialization and more systematic experimentation with left-handed children would seem warranted.

Although learning-disabled children have been studied extensively, no studies have examined homogeneous groups of bilingual or strongly left-handed children utilizing the dichotic listening technique. Therefore, this study attempts to examine the hemispheric specialization for language of three presumed anomaly groups (right-handed learning-disabled, right-handed bilingual, and left-handed children) and a fourth, right-handed control group, utilizing the dichotic listening task and controlling for attentional bias through the use of cued procedures.

METHOD

Subjects

A sample of 60 middle-class socioeconomic status elementary school students ranging in age from 7 years, 1 month to 13 years, 7 months (X=9.9 years) participated in the study. Fifteen subjects (8 male, 7 female) from officially designated learning disability programs were selected for one group; 15 subjects (9 male, 6 female) demonstrating strong left-handedness comprised a second group; while 15 subjects (8 male, 7 female) from bilingual instructional programs were selected for a third group. In addition, 15 subjects (10 male, 5 female), similar in age and IQ to the other three groups, were selected to serve as a control group. All control, learning-disabled and bilingual subjects preferred the right hand, using a cutoff score of seven of eight activities from the Edinburgh Handedness Inventory. Left-handed subjects preferred the left hand, using the same cutoff score.

Mean laterality quotients (LQ) were as follows: control subjects LQ=97.52; learning disabled subjects LQ=98.34; bilingual subjects LQ=100.00; left-handed subjects LQ= =-91.67. In addition, no subject was included if he/she had: (1) a history of seizures or other neurologic disorders, or (2) a history of speech/ hearing disorders.

Apparatus

Thirty pairs of synthesized consonant-vowel-consonant (CVC) syllables differing only in initial consonant, (i.e., beb/deb/keb/geb/peb/teb/) were dichotically presented through a TEAC A-2300SX 2-channel tape recorder. The test stimuli were received through KOSS K-6 stereophonic headphones at a hearing amplitude of 70 dB. A calibration tone on the tape recorder was used to monitor each channel. The ambient noise level was 40 dB. The presentation of the CVC syllables represented all possible nonidentical pairings of the dichotic stimuli, with an interpair interval of 6 sec.

Procedure

Three sets of CVC's with 30 trials each were given to each child in an attempt to assess the subject's ability to direct attention. The first condition involved free recall (FR), a second involved a directed right ear report (DR), and a third asked for a directed left ear report (DL). The child was instructed before the directed conditions to report what was heard only in a particular ear. Also, the subjects were instructed to maintain their gaze straight forward (central hemispace) during all trials. After each set of 30 trials, the tape was rewound and the directions were reviewed for the new condition. In the free recall condition, the child was asked to listen carefully and report only one CVC per trial.

Results

The mean percentage left-and right-ear correctly reported CVC stimuli according to diagnostic group and dichotic listening condition are reported in Table 1.

Insert Table 1 about here

A 4 group (control, left-handed, bilingual, learning-disabled) x 3 dichotic condition (free recall, directed left, directed right) x 2 ear presentation (left, right) analysis of variance (ANOVA) with repeated measures on the last factor was conducted. Results of the ANOVA revealed three main effects and four interaction effects. There was a significant group difference, $F(3,56) = 4.28$, $p<.01$, with the bilingual children demonstrating lower overall performance than the other three groups. However, the control, left-handed and learning-disabled groups did not differ

significantly from each other on overall perfomance. The main effect for ear, $F(1,56)= 27.58$, $p < .001$, suggested the presence of a REA, although this needs to be interpreted in light of the interactions because group differences for ear were also found. The main effect for report condition, $F(2,112)=3.48$, $p<.05$, showed that performance changed across condition with the lowest overall performance occurring in the free recall condition. No differences in performance were found between the directed left and directed right conditions. As noted earlier, the foregoing needs to be interpreted in light of the significant 2- way interactions between ear and group, $F(3,56) = 7.98$, $p < .001$, condition and group, $F(6,112)= 5.86$, $p<.001$, ear and condition, $F(2,112) = 40.20$, $p<.001$, and more importantly, the 3-way interaction among ear, group and condition, $F(6,112) = 2.75$, $p<.05$. Post-hoc analyses of simple effects were conducted with Tukey's test, selected to maintain alpha for the entire set of pairwise comparisons.

As can be seen by referring to table 1, the expected REA was contingent on both the dichotic condition and group membership. In order to examine these effects more specifically, follow-up tests were also conducted on the previously reported significant 3-way interaction. We chose to compare the control (right-handed) group to the other groups since left-handers, bilinguals and learning-disabled may not represent a single continium.

Controls

Analysis of simple effects suggested that controls produced a constant REA across free recall, directed left, and directed right, conditions. In addition, while control children did not show differences in LE report across conditions, RE report significantly increased between free recall and the directed right condition, with no such change observed between free recall and the directed left condition.

Left-Handers

Analysis of simple effects suggested that left-handers produced an LEA in free recall, and in the directed left condition, while a non-significant REA trend was found in the directed right condition. Although left-handed children did not show differences in RE report across conditions, LE report significantly decreased between free recall and the directed right condition with no change observed between free recall and the directed left condition.

Bilinguals

Analysis of simple effects suggested that bilingual children produced an REA in free recall, and in the directed right condition, while there was no difference found between RE and LE report in the directed left condition. In the directed left

condition, LE report increased and RE report decreased to the extent that the REA was not obtained. As noted, the largest between ear difference was found in the directed right condition with no measurable ear effect found in the directed left condition.

Learning-Disabled

Analysis of simple effects suggested learning-disabled children produced an REA in free recall, and in the directed right conditions, with no ear differences found in the directed left condition. Unlike control and bilingual groups, these children significantly increased their LE report from free recall to the directed left condition, with no significant change between free recall and the directed right conditions. However, RE report increased significantly between free recall and the directed right condition, while RE report remained constant between free recall and the directed left condition, much like left-handed children did in the directed right condition.

The data were also analyzed using the laterality index, lambda, (λ) developed by Bryden and Sprott (7). This procedure provides a way of compensationg for individual differences in overall accuracy, as well as providing a significance test for each subject. Because the free recall and directed attention procedures place somewhat different demands on the subject, the appropriate lambda analyses involved treating these as two distinct experimental procedures.

Free Recall

In the free recall task, subjects were permitted only one response on each trial. An REA, therefore, is indexed by how often this one response is drawn from the RE rather than the left. Thus, λ for this task is determined by In(Correct R/Correct L). Mean λ values for the different groups were: controls Ø.36; left-handers -Ø.45; bilinguals Ø.43; learning-disabled Ø.49. Only the control and left-handed groups differed significantly from one another ($t(28) = 2.49$, $p < .Ø1$). The limited number of trials precludes many subjects from showing highly significant ear effects, but it seems appropriate to consider a subject as showing an ear effect when the evidence is at least reasonable. In the present study we classified subjects as showing LEAs or REAs when the significance test exceeded the two-tailed .25 level ($z > + 1.15$) [(cf. Wexler & Halwes (46)]. By this criterion, the left-handers (6 LEAs and 1 REA) differ clearly from all the right-handed groups (controls, 4 REAs; bilinguals, 1 LEA and 8 REAs; learning-disabled, 6 REAs). The individual subject analysis, therefore, corroborates the overall analysis of values.

Directed Attention

Analyzing the directed attention conditions is a bit more complicated, in that a subject can respond in one of three ways on any trial. Given instructions to attend to a specified ear and report the item at that ear, a subject can do so correctly (C), give the item from the other ear, an intrusion (I), or be totally wrong, an error (E). Analysis depends on whether the intrusions are considered as errors or as akin to correct responses in that they provide evidence for some information getting through. The consequence is that there are several alternative ways of applying the lambda statistic.

Perhaps the most obvious measure of laterality is what we have called an "accuracy" lambda. In this analysis, both errors and intrusions are considered to be mistakes, and are combined. The lambda, then, compares the likelihood of identifying the RE item when attending to the right to the likelihood of identifying the LE item when attending to the left. Thus, $\lambda = \ln (RC)(LI+LE)/(RI+RE)(LC)$. The mean λ values for the four groups were controls 1.20; left-handers -0.27; bilinguals 0.70; learning-disabled 0.71. A one-way analysis of variance indicated that the group means were different ($F(3,56) = 6.96$, $p < .001$). As with the free recall task, left-handers differed from control right-handers ($t(28) = 3.60$, $p < .01$), but neither bilinguals nor learning-disabled children differed from the control children. On an individual subject basis, 9 controls showed significant REAs at the .25 level. Among the bilinguals, there were also 9 REAs; there were 8 REAs and 1 LEA among the learning-disabled, and 5 LEAs and 2 REAs among the left-handers.

A second lambda computation is what we have termed a "detection" lambda. It considers intrusions as equivalent to correct responses, and combines these two values. In effect, it compares the likelihood of identifying something that was there when attending to the right as opposed to attending to the left. In many ways, it tests the hypothesis that children found it easier to attend to one ear than to the other. It is therefore not truly a laterality measure, and should not be expected to reveal a strong right-ear bias. The detection lambda is defined as $\ln[(RC+RI)(LE)/(RE)(LE+LI)]$

The mean values obtained for the detection index were: controls 0.09; left- handers -0.33; bilinguals 0.06; learning-disabled -0.07. Although a one-way analysis of variance failed to reveal any significant difference among the groups ($F(3,56) = 1.39$, n.s.), the left-handed group did differ from the control right-handed group by a t-test ($t(28) = 2.17$, $p < .05$). The left-handers did show a slight tendency to perform better when attending to the LE, while the other groups showed virtually no biases. Tests on the individual subjects revealed similar patterns. None of the control children showed significant ($p < .25$) lambdas, and only one learning-disabled subject showed a right bias. Among bilinguals, 2 showed left biases and 3 right

biases, while 3 left-handers showed left biases.

The final lambda calculation we have termed a "localization" lambda; it follows from the detection lambda. It considers only those trials on which a subject has shown some evidence of detecting something -- those considered "correct" in the detection analysis -- and determines whether more come from the RE or the LE. Therefore, the localization $\lambda = \ln (RC)(LI)/(RI)(LC)$. Mean values for the localization lambda were: controls 1.46; left-handers -0.08; bilinguals 0.89; learning-disabled 0.62. A one-way analysis of variance indicated that the groups differed significantly ($F(3,56) = 4.53$, $p < .01$). Left-handers differed from control right-handers ($t(28) = 2.89$, $p < .01$), but neither bilinguals nor learning-disabled differed from the control group. Individual subject tests indicated strong right-ear effects in all groups (controls: 9 REAs; bilinguals: 12 REAs; learning-disabled: 1 LEA and 6 REAs) except the left-handers (5 LEAs and 3 REAs).

Conclusions

The purpose of this study was to investigate differences in language lateralization among children with presumably anomalous cognitive processing abilities. The specific objective of the research was to examine laterality effects as measured by dichotic free recall and cued report among right-handed (control) good readers, right-handed bilingual readers, left-handed good readers and right-handed learning-disabled readers. These groups all are suspected of using different strategies to process language some of which may be more efficient than others. By controlling for attentional bias through the use of cued dichotic recall, one may learn the mechanisms underlying each groups' language structure and subsequent learning styles.

In conclusion, the free recall group data indicated that control, bilingual and learning-disabled children produced the REA suggestive of left hemisphere dominance for language processing, whereas left-handed children produced an LEA suggestive of right hemisphere superiority for language. However, the cued attention data on groups as well as on individual subjects provided specific insight regarding the mechanisms of attention in interaction with hemisphere specialization. Specifically, the considerable variability of the left-handed children on these tasks indicates that some subgroups of left-handers may not be able to demonstrate sufficient suppression of the nondominant hemisphere. Consequently, attentional factors have a greater influence on asymmetrical functioning for some anomalous groups of children.

Table 1

Mean Percentage of Left-Ear and Right-Ear Correct Report by Diagnostic Group and Dichotic Condition

		Free Recall		Directed Left		Directed Right	
Group	N	LE	RE	LE	RE	LE	RE
Control	15						
M		31.66	45.20	32.80	52.46	26.26	59.86
SD		5.72	5.36	11.05	11.53	11.22	12.78
Left-Handed	15						
M		49.73	33.33	48.80	33.00	32.66	44.13
SD		14.70	14.35	15.56	14.78	15.90	14.81
Bilingual	15						
M		31.00	46.53	33.20	40.80	25.26	49.26
SD		10.02	11.68	8.35	10.94	7.09	8.50
Learning Disabled	15						
M		29.20	46.60	41.86	43.73	26.80	58.66
SD		9.18	8.80	11.19	12.98	9.92	8.79